LCA Case Studies

Including the Use Phase in LCA of Floor Coverings

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Abstract. The results from two previously published case studies were used to assess the importance of use-related emissions from building materials in a life cycle perspective. The first study was an LCA study of linoleum, vinyl flooring, and solid wood flooring, while the second study examined the Volatile Organic Compounds (VOCs) emitted by these floorings. For linoleum and vinyl flooring, the emitted amounts for the use phase are of much the same magnitude as those emitted in the rest of the life cycle, but in the case of solid wood flooring the emissions of the use phase far exceed those of the remaining life cycle. The ranking of the selected floorings in the LCA study did not change when the impact of the use phase was also considered. This study recommends that LCAs should not neglect flooring-related emissions in the use phase when assessing regional and global environmental effects.

Keywords: Emissions; floorings; indoor climate; LCA; Life Cycle Assessment; linoleum; solid wood flooring; TVOCs; use phase; vinyl flooring; VOCs; Volatile Organic Compounds

1 Introduction

Life Cycle Assessment (LCA) is frequently used in the environmental assessment of building products. LCAs usually focus on external regional and global environmental effects, without considering how these effects are distributed in time and space. However, a considerable part of the environmental problems related to the building arise locally in connection with the indoor environment, like effects on human health.

Product-related LCAs show that the environmental impact of the use phase varies between products. For products like cars and refrigerators, the effects of the energy consumption of the use phase generally exceed other impacts in importance, while the use phase has no such impacts for other products, such as packaging materials and paper. For buildings as a whole, the energy consumption of the use phase generally has a considerably higher environmental impact than other parts of the life cycle. While not all impacts of the use phase may be directly related to the building products used, those that are include material-related emissions and the impacts of products and processes involved in use and maintenance. Most of these emissions arise from surface materials such as floor coverings. Volatile Organic Compounds (VOCs), often aggregated as total VOCs (TVOCs), are a frequently studied group of emissions.

In 1993 - 95, two case studies were conducted to assess the environmental impact of selected floor coverings. The first was an LCA study of three flooring materials (Jönsson et al., 1997, hereafter referred to as the LCA study), while the second study measured indoor air emissions from these types of floorings (Johnson, 1995, from now on called the VOC study). In this paper, the results of the two case studies are considered in relation to one another.

1.1 Objectives and scope

The objectives of this study were

- To assess the environmental impact of floorings over their entire life cycle, including the use phase
- To investigate the specific impacts of flooring-related emissions during use from a life-cycle perspective, and to investigate how these compare to the total impacts of the remainder of the life cycle
- To assess whether the conclusions drawn in the LCA study regarding the most environmentally benign floor covering still stand when the emissions of the use phase are also considered.

Flooring materials were chosen for study because they are surface materials and thus may affect the indoor climate during the use phase. *VOCs* were studied because they are considered the most important emissions from building products to indoor air, and they are also well documented. The LCA study covered floorings for use in *residential buildings*, while the VOC study included floorings for domestic and public use in a *non-industrial* indoor environment.

In studying the use phase, only the environmental impact of flooring material as such was considered. The impacts of *cleaning and maintenance* were not addressed, partly because of a lack of relevant data, but also because the frequency of these activities and the selection of cleaning agents in residential buildings can be assumed to depend more on personal cleaning habits than on the choice of floor covering. Likewise, the *energy consumption* of the use phase is not dealt with as this is not affected by the choice of floor covering, although this use of energy is crucial when considering the environmental impact of the building as a whole from a life-cycle perspective.

2 Terms and Definitions

2.1 LCA methodology

Life Cycle Assessment (LCA) is a method of analysing and assessing the environmental impact of a material, product

or service throughout its entire life-cycle, usually from the acquisition of raw materials to final disposal. International standardisation of LCA is being done under the auspices of the ISO (ISO 14040, 1997). In LCA, all data are related to a basis for comparison; a *functional unit*, defined as the quantified performance of a product system. LCA results are normally presented as the aggregate environmental impacts related to the functional unit, without regard to their distribution in time and space. However, attempts have been made to include site-dependent effects in LCA (see for example FAVA et al., 1992; UDO DE HAES et al., 1996; POTTING and HAUSCHILD, 1997).

2.2 VOCs from floor coverings during the use phase

Volatile organic compounds (VOCs) are generally defined as *those organic compounds that have a boiling point in the interval from 50 - 100 to 240 - 260°C*. A mixture of VOCs is often aggregated on a mass basis and referred to as *Total VOCs (TVOCs)*. There are a variety of ways of calculating a TVOC value, and there is as yet no standardised procedure for how this should be done (ECA-IAQ, 1997). In the literature, the term VOCs is sometimes also used for aggregated VOCs; however, in this paper, the term TVOCs is consistently used to refer to aggregated measures of VOCs, and the term VOCs is used only when referring to specific compounds or to this group of organic compounds as a whole.

Generally, indoor air contains many VOCs arising from various sources. Both the concentration of specific VOCs and the TVOC value vary widely over time and space indoors. The VOCs themselves also differ widely in their environmental effects. There is extensive literature on the relation between TVOCs and health in non-industrial indoor environments (see, for example, ANDERSSON et al., 1997).

Various building materials have been identified as emission sources in buildings (GUSTAFSSON, 1990). VOCs and TVOCs are frequently used as a measure of the contribution of VOCs from building materials, especially surface materials such as floor coverings, to indoor air. There are guidelines and trade standards on how to measure emissions from building materials (see, for example, GBR, 1992; NIELSEN and WOLKOFF, 1993; ECA-IAQ, 1997). So far, no regulations have been imposed on emissions from building materials; rather, regulatory bodies have merely encouraged the selection of low-emitting materials (MARONI and LUNDGREN, 1998).

3 The Use Phase in Flooring-Related LCA: Recent Research

Flooring-related environmental impacts during the use phase derive from emissions from the materials and from cleaning and maintenance. In LCA studies of floor coverings, impacts from the use phase have been handled in different ways.

A Dutch LCA study of floor coverings for domestic use (POTTING and BLOK, 1995) omitted the impact of cleaning and maintenance on the assumption that it is impossible to make generalisations about this, and because vacuum cleaning appears to be the main method of maintenance in domestic situations. Nevertheless, over the lifetime of a product, it was noted that vacuum cleaning can use large amounts of energy. VOCs emitted from the floorings during use were not taken into account.

In another LCA study of 32 European floor coverings for commercial and light industrial applications (GÜNTHER and LANGOWSKI, 1997), the impacts of cleaning were taken into account. The conclusion was that, over the lifetime of a typical flooring, more energy may be spent on contract dry cleaning than was required to produce the flooring. Emissions during the use phase were not studied for two main reasons: a) The available emission data on the products studied varied widely in magnitude and quality for the same types of floorings, and b) a lack of toxicity data on many of the substances emitted. Moreover, the main focus of this study was not on locally relevant environmental impacts.

In an LCA study comparing the environmental impact of vinyl flooring and polyolefine flooring (LUNDBLAD, 1994), the contribution of cleaning agents and finishes to the total environmental impact of the floorings was taken into account. One of the findings was that the environmental impact of flooring maintenance may sometimes exceed the impact of the life cycle 'from cradle to gate'. However, the study addressed floorings in public buildings where cleaning is performed professionally, and it may be assumed that considerably lower quantities of cleaning agents and finishes are used for floorings in residential buildings. The VOC emissions during the use phase attributable to floorings, cleaning agents and finishes were not considered in this study.

According to Johnson (1995), VOC emissions from floorings vary considerably depending on the products used for surface treatment. A Swedish study (SP/GBR, 1995) examined the extent to which emissions from linoleum and vinyl flooring are affected by surface treatment with wax floor care and cleaning agents. This study found that the various surface treatments had no effect on VOC emissions. Franke et al. (1997) found that instituting an organised cleaning program, and thus improving the cleaning of a building, decreased TVOC concentrations in air by 49% (however, this decrease was not statistically significant). Cleaning products with a lower TVOC content than average were used during the program. While there were temporary increases in the TVOC concentrations in the air during cleaning, these effects were short-lived. On the whole, the improved cleaning routines effected a general improvement in the indoor air quality.

None of the LCA studies discussed above took into account emissions from flooring during the use phase, most likely because local, site-dependent impacts are methodologically difficult to address in LCA, and also because of a lack of relevant data. The environmental impacts of cleaning and maintenance were more often taken into account, although more because of their life-cycle impact than because of the contribution of their emissions to indoor air.

4 The LCA Study

The LCA of flooring materials assessed and compared the environmental impact of linoleum, vinyl flooring, and an untreated solid pine wood flooring over their life cycles

(JÖNSSON et al., 1997, presented in more detail in JÖNSSON, 1995). The objective was to compare the environmental impacts of the life cycle of specific flooring materials and also to develop the methodology of LCA in its application to building products. The scenarios used assumed that the flooring was installed in residential buildings in a Swedish location. The functional unit chosen was *the covering of one square metre of flooring for one year.* The environmental impact of the use phase was omitted, as described in section 1.1. The parameters considered were use of natural resources, use of energy, emissions to air and water, and generation of waste. The average lifetime of the flooring was estimated to be 25 years for linoleum, 20 years for vinyl flooring, and 40 years for wood flooring.

The inventory results were first related to the functional unit and evaluated on this basis. **Table 1** presents the VOC emissions that could be related to the life cycle (excluding the use phase) of the floor coverings. The categories overlap in some respects, but are nevertheless presented separately in the table owing to the form in which data was gathered. It should be noted that data in Table 1 refers to the entire life of each of the floorings, and does not take the differences in their life-spans into account.

None of the VOCs represented in Table 1 are assumed to affect the indoor air in residential buildings, for the data refers either to industrial emissions or to emissions from diffuse sources, such as transportation. The parameters were chosen on the basis of the data that was available at the time of the inventory. Because many fundamentally different processes may be part of a product's life cycle, there are differences in the specific VOCs measured in each process, and in the extent to which these measures have been aggregated. The values for VOC emissions incorporated in the inventory were sometimes available as specific VOCs and sometimes as aggregated values (→ *Table 1*). Consequently, for each flooring, a TVOC value constituting an aggregated value of all VOCs related to that flooring, as presented in Table 1, had to be used when comparing the three floorings, and evaluating the results. According to the inventory, linoleum is associated with the highest TVOCs, whereas solid wood flooring has the lowest emissions. However, the differences between the floorings were not large, given the uncertainty of the data. Only domestic floorings were studied, but as most VOCs (i.e. the process emissions) were allocated on the basis of surface area, the calculated TVOCs per square metre would be similar for floorings in domestic and public use.

Three quantitative weighting methods (see section 6.2), each resulting in a single value, were used to interpret the inventory results, including TVOCs and all other parameters considered. According to the first set of results, solid wood flooring was clearly the most environmentally sound flooring. Linoleum was ranked as more environmentally sound than vinyl flooring, although the difference between the two was slight when compared to the results for solid wood flooring. Reanalysis using more recent data on the production of titanium dioxide (which is the pigment most commonly used) reduced the impact assessment values of both linoleum and vinyl flooring. Vinyl flooring was then rated as having the highest environmental impact by all three weighting methods.

5 The VOC Study

The emissions of VOCs to air by eight different floorings and three paints were studied in order to determine the extent to which these emissions during the use phase contrib-

Table 1: VOC emissions of floorings in grams per square metre over the life cycle excluding the use phase. (Based on JÖNSSON et al. 1997)

Flooring	Amount	Unit	Dominant activity
Linoleum			
VOCs	5.87	g/m^2	linoleum flooring production
solvents	3.12	g/m^2	linoleum flooring production
terpenes	0.03	g/m^2	powdered wood production
TOTAL:	**9.02**	g/m^2	
Vinyl flooring			
HC	1.94	g/m^2	fossil fuels (processing and transports)
ethylene	0.06	g/m^2	PVC production
CH_4	3.08	g/m^2	vinyl flooring production
VOCs	1.95	g/m^2	vinyl flooring production
EDC/EC/VCM	0.56	g/m^2	PVC production
TOTAL:	**7.59**	g/m^2	
Solid wood flooring			
HC	0.98	g/m^2	fossil fuels (transport)
terpenes	3.33	g/m^2	wood
TOTAL:	**4.31**	g/m^2	

ute to the total life-cycle impact (JOHNSON, 1995). The present paper considers only the data on floorings (vinyl flooring, linoleum and solid wood flooring). The floorings chosen were modern, commercially-available, low-emission floorings produced in 1992 - 93. The investigation did not cover the maintenance of the materials.

The measurements were performed using a small model test chamber, FLEC (Field and Laboratory Emission Cell). Pumped air samples were collected on a solid adsorbent (Tenax TA). The total emission of VOCs and major single compounds were analysed. VOCs are here defined as substances caught in a Tenax TA adsorber that are thermally desorbable. The measurements were performed according to Swedish trade standards (GBR, 1992). As there were differences in off-gassing time, the measurement period varied from six months to two years, depending on the flooring. TVOC and VOC values (i.e. aggregated totals and values of specific major components) from the use phase were extrapolated. To make the emission data usable as input data in LCA, the total amount emitted over the use phase was then assessed.

The floorings differed widely in regard to the specific VOCs emitted. They also differed in the pattern of emissions. For most floorings, the emissions tended to decrease exponentially, but in some cases the emissions remained almost constant or even increased slightly with time. This made it difficult to estimate the total amount emitted without measuring over a longer period. In the calculations, an exponential off-gassing rate was assumed for most floorings, but for some products an assumption of linear off-gassing was more appropriate (→ *Table 2*). **Table 2** shows the calculated TVOC emissions over the lifetimes of the floorings included in the study, based on measurements and the assumptions discussed above.

The results show rather large variations, both between the types of flooring and within each type. The products studied are so few that it cannot be seen if there are any differences between floorings for domestic use (the thinner products) and for public use.

Information from a database held by the Swedish National Testing and Research Institute was used in a study of 31 flooring materials (GUSTAFSSON and JONSSON, 1993, cited in MARONI and LUNDGREN, 1998). In this study, it was found that the median emission rate of TVOCs was 294 µg/h,m² four weeks after production. Two years after that study, a new set of 13 flooring materials was studied and the corresponding value was then 60 µg/h,m², which indicates a general improvement over this period (MARONI and LUNDGREN, 1998). The measurements in the VOC study (→ *Table 2*) lie between these two median values and may therefore be regarded as not representing extreme products.

6 Results from Combining the Case Studies

6.1 Inventory results

Fig. 1 shows the TVOCs found in the LCA study as compared to the results of the VOC study. All data was related to the functional unit by distributing the emissions over the estimated lifetimes. All emissions found in the LCA study emanate from processes before use, and thus those results provide a cradle-to-gate perspective on VOCs. The products in the two case studies were not exactly the same, and thus the emission data on the use phase is derived from those products judged to be most similar to the products included in the LCA study (for vinyl flooring, this was judged to be the average of the data for floorings 1b and 1c; for linoleum, it was 2a; and for wood flooring, 3c). As the estimated average lifetimes used in the LCA study exceed the assumed off-gassing times for these floorings (→ *Table 2*) the total calculated TVOC values were used.

Table 2: VOC emissions from 8 floorings, expressed as TVOCs per square metre during their lifetime. (Based on JOHNSON 1995)

	Type of flooring	Off-gassing rate 4 weeks[1] (µg/m²h)	Off-gassing rate 26 weeks[2] (µg/m²h)	Calculated TVOCs over the use phase (g/m²)
1a)	Vinyl (homogeneous, 2.0 mm, PUR top layer)	–	<10 (detection limit)	1.3
1b)	Vinyl (2.3 mm, PUR top layer)	118	40	1.8
1c)	Vinyl (2.3 mm, PUR top layer)	140	115	3.3, 6.6 or 9.8[3]
2a)	Linoleum (2.0 mm)	182	50	4.5[4] or 4.9[5]
2b)	Linoleum (2.5 mm)	160	75	5.8[4] or 6.25[5]
3a)	Wood (14 mm, laminate parquet)	250	100	25[6]
3b)	Wood (14 mm, laminate, beech top layer, oiled)	620	250	20
3c)	Solid pine wood (25 mm, untreated)	420	75	23

[1] Maximum measure, obtained at the start of the measurements (4 weeks after production).
[2] Rounded-off values
[3] Linear off-gassing times of 5, 10 or 15 years assumed.
[4] Linear off-gassing time of 15 years assumed.
[5] Linear off-gassing time of 15 years assumed. Measured contribution from first six months included.
[6] After an initial decline, the level of off-gassing was assumed to be constant over 15 years, followed by linear off-gassing.

When TVOCs are distributed over the lifetimes used in the LCA study, the amounts emitted by the different types of flooring are fairly even on a yearly basis (→ *Fig. 1*). For linoleum and vinyl flooring, the emitted amounts for the use phase are of much the same magnitude as those for the previous part of the life cycle, but, in the case of solid wood flooring, the emissions of the use phase far exceed those of the cradle-to-gate phase.

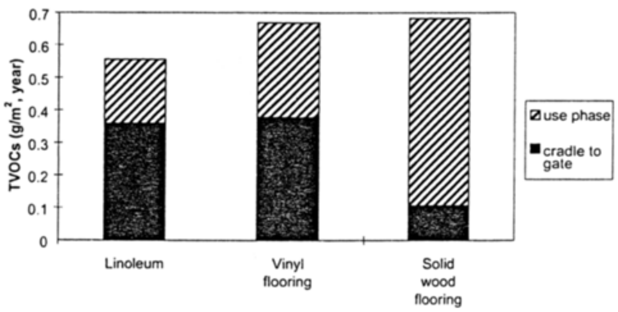

Fig. 1: TVOCs for three floor coverings, distributed over their lifetimes. Average lifetimes assumed: 25 years for linoleum, 20 years for vinyl flooring and 40 years for solid wood flooring

6.2 Impact assessment results

The next point to be investigated was the contribution of TVOCs to each flooring's total environmental impact over its life cycle, including all impact categories assessed in the LCA study. The quantitative results of the inventory analysis were evaluated using the same three weighting methods that had earlier been applied in the LCA study:

- The *Environmental Priority Strategies in Product Design method (EPS)*, developed in Sweden (Steen and Ryding, 1993)
- The *Environmental Theme Method*, developed in the Netherlands (Heijungs et al., 1992) and adapted to Swedish conditions (REFORSK, 1993)
- The *Ecological Scarcity Method*, developed in Switzerland (Ahbe et al., 1990) and adapted to Swedish conditions (REFORSK, 1993).

For the LCA study, the second set of results referred to in section 4 were used in the calculations. **Fig. 2** shows that the contribution of TVOCs to the total weighted result was minor, except for solid wood when using the Ecological Scarcity Method.

Obviously, the environmental impact of the use phase does not affect the ranking of the floorings. When using the EPS method, the VOCs for which indices are available (CH_4 and ethylene) are not among the dominant emissions during use, and thus this method yields the same results regardless of whether the use phase is taken into account. The other two weighting methods have specific indices for TVOCs, but these indices were designed with the contribution of VOCs to external, regional and global effects in mind. Thus, in the results presented in Fig. 2, the potential indoor climate effects of VOCs emitted during the use phase are disregarded. The total impact was higher for the vinyl flooring than for the other floorings that had an equivalent impact. This was also the finding of the LCA study. However, a study of the distribution over the life cycle using one weighting method (the Eco-scarcity method) revealed that the TVOCs emitted during the use of solid wood flooring were responsible for about half of the total impact (→ *Fig. 3*).

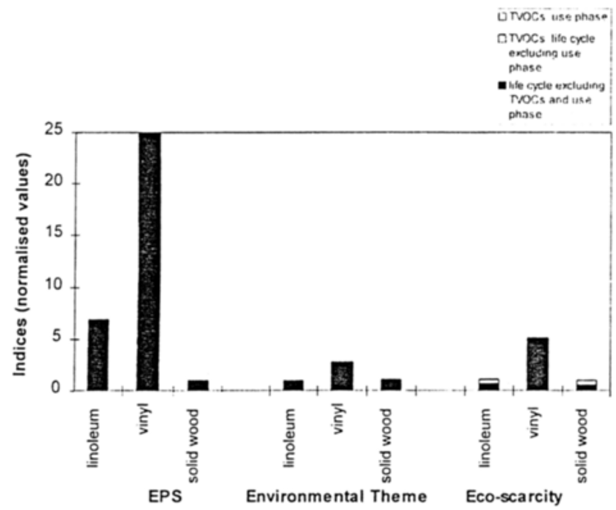

Fig. 2: The environmental impact of different types of flooring and the contribution ofTVOCs as assessed by three quantitative weighting methods. Data are normalised in relation to the lowest aggregate value within each method. Data are not comparable across methods

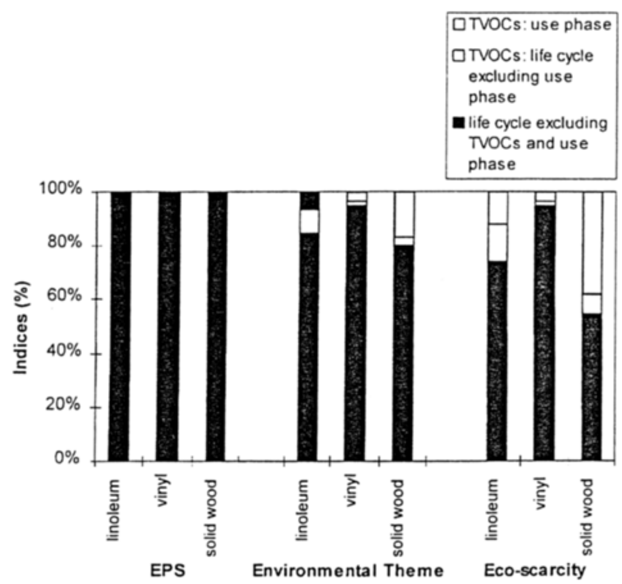

Fig. 3: Relative contribution ofTVOCs to the impact of floorings on the external environment

Floorings for domestic use, which were the focus of the LCA study, are generally thinner than products for public use, and they consequently use lower quantities of raw materials per square metre. If LCA data for public floorings was used in the impact assessment, it is probable that the relative importance of TVOCs compared to other impacts would decrease even more.

7 Flooring Related VOCs vs. Other VOC Emissions

7.1 Floorings as a source to indoor TVOCs

Data from the VOC study was used to assess the contribution of flooring to TVOC concentrations in indoor air. A room height of 2.3 m and an air flow of 0.3 l/m^2,s was assumed, representing a common Swedish situation. In the VOC study, the floorings with the highest emissions were chosen, and it was assumed that the air was evenly distributed in the room. No account was taken of the fact that flooring-related VOCs emitted in a building differ to some extent from the same emissions measured in chambers or cells, and that VOCs in indoor air interact with surrounding surfaces, etc.

Table 3: Calculated contribution of emissions from floorings to TVOC concentrations in a room. (Based on data from Johnson 1995)

Flooring type	Peak measure (4 weeks) (µg/m^3)	26 weeks (µg/m^3)
Linoleum	170	45
Vinyl flooring	130	100
Solid wood flooring	570	230

A nation-wide survey of the indoor climate in Swedish residential buildings estimated that the average TVOC concentrations in indoor air were 470 µg/m^3 in single-family houses and 310 µg/m^3 in multi-family houses (Norlén and Andersson, 1993). Comparison of the calculated TVOC concentration due to floor coverings with typical TVOC concentrations in indoor air shows that early in the use phase, floorings could be a significant contributor to the TVOCs in indoor air. Experiments have shown that irritation of the eyes, nose and throat by poor indoor air quality is first experienced at TVOC concentrations from 5000 to 25 000 µg/m^3 (Andersson et al., 1997), which is far above the typical indoor concentrations and the calculated concentrations due to floor coverings.

7.2 Indoor TVOCs as a source to external TVOCs

VOCs in indoor air end up in the external environment when the air in the building is exchanged. To assess the relative importance of flooring and indoor climate-related TVOCs on a non-local scale, the results of the case studies were related to Swedish TVOC emissions.

In 1994, the *total Swedish TVOCs* attributable to anthropogenic sources were estimated to be around 460 ktonnes, with road transportation and off-road machines as the most important contributors (SNV, 1996). Of these, about 40 ktonnes were emitted by *households*, mainly from paints, varnishes, sanitary products, and products for car maintenance. Emissions from floorings are not included in this value. VOCs from trees and sawmills are also not included in the statistics, and therefore the actual values for Swedish TVOCs are probably considerably higher than the value given.

The annual *TVOC output from the indoor environment* (e.g. from building materials, activities, smoking and people) was calculated to be 1.4 ktonnes, which is roughly equivalent to 0.3% of total Swedish VOC emissions in 1994. Statistics for the Swedish building stock surface for non-industrial buildings in 1995 were used. The following assumptions were made: the average TVOC content in indoor air is 400 µg/m^3, the average ventilation rate is 0.3 l/s, m^2, and the estimated average contribution of TVOCs from outdoor air to the indoor concentration is 30%. The overlap between calculated emissions from the indoor environment and household-related TVOCs is assumed to be relatively small, as most of the products addressed in the statistics are either used for only a short period, and therefore do not affect measures of indoor VOC concentrations, or are not used indoors.

TVOCs emitted from floorings during the use phase may be estimated to around 200 tonnes/year, which is roughly equivalent to 0.05% of the total Swedish TVOCs, 0.5% of household-related TVOCs, and 15% of indoor TVOCs emitted to the external environment. The calculations are based on data from the VOC study and on flooring market statistics. It was assumed that all VOCs are emitted during the first two years of use. This is not really the case according to the VOC study, but the overestimation of emissions from floorings less than two years old is compensated for by the underestimation of emissions from older floorings. As the VOC study focused on low-emission floorings, the calculated emissions are probably on the low side. Table 4 summarises the results of the comparisons discussed above.

Table 4: Annual TVOC emissions in Sweden

TVOC source	Amount (ktonnes/year)	Data source
All anthropogenic activities	460	SNV (1996)
Households	40	SNV (1996)
Indoor air	1.4	Statistics, assumptions made
Floor coverings (use phase)	0.2	Case study by Johnson (1995), statistics, assumptions made

8 Conclusions

Analysis of the results from the case studies shows that the TVOCs emitted by floor coverings during the use phase are of much the same magnitude as the TVOCs emitted in the rest of their life cycle. However, there are variations between different types of flooring. Emissions during use are the most important ones in relation to solid wood flooring, for which they constitute some 85% of the total TVOCs.

When three weighting methods were applied to the compiled inventory results of the case studies, the TVOCs emitted during the use phase seemed to make a relatively small contribution to the overall life cycle impact, except in the case of solid wood flooring where those emissions played a significant role. However, the VOC and TVOC indices in the weighting methods were created with external, regional and global effects in mind, and, thus, the effects on indoor climate were not considered. This present study found that the contribution of TVOCs emitted from floorings during the use phase is a relevant factor to be included in LCA, even when considering only external effects. So far, there are no indices for the health

effects related to indoor VOCs. The possibility of creating such indices is discussed in Jönsson (1998).

Statistics, data from the VOC study, and assumptions contributed to the conclusions regarding the relative importance of flooring-related TVOCs during use. It was found that early in the use phase, floorings contribute significantly to TVOC concentrations in indoor air. The yearly estimated TVOC contribution from indoor air is about 0.5% of total Swedish TVOC emissions. The total calculated TVOCs emitted from floorings constitute about 0.05% of the total Swedish TVOC emissions.

9 Discussion

Indoor concentrations of TVOCs from floorings are usually not enough in themselves to cause health effects, but in combination with other indoor sources of VOCs (e.g. consumer products and activities in the building), they could contribute to health effects. This means that knowledge of the background concentrations in indoor air is crucial when evaluating the health effects of flooring-related VOCs.

When one attempts to assess the environmental impact of VOCs, one finds that the LCA data, the data on use-related emissions from building products, and the national statistics differ in regard to which specific VOCs are measured and how the data is aggregated. Therefore, although comprehensive information is available on VOC emissions related to buildings and their components, such data is not easily compared when assessing the harmfulness of a specific quantity or concentration. Differences in the effects of specific VOCs were recognised but not addressed in this study. Instead, the data was aggregated into TVOCs when it came to evaluating the results. Detailed knowledge of TVOCs is necessary if the input data and results are to be handled correctly.

The results of a nation-wide Swedish survey indicate that between 600 000 and 900 000 people, that is about 10% of the Swedish population, reside in dwellings with an indoor climate that affects health and well-being (Norlén and Andersson, 1993). The contribution of floorings to total Swedish TVOC emissions is so small that, despite the rough assumptions made, it can be claimed that where VOCs emitted from floorings contribute to a poor indoor climate, these emissions constitute a more serious problem for the indoor climate than for the external environment.

There are great methodological differences between LCA and indoor climate assessment. The methodological similarities and differences between LCA, VOC measurements from building materials and indoor climate assessment are described in more detail in Jönsson (1998).

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Conference Announcements

Tribology in Environmental Design 2000

The Characteristics of Interacting Surfaces:
A Key Factor in Sustainable and Economic Products
First International Conference, 3 – 6 September 2000, Bournemouth, United Kingdom

Delegates from industry and academia are invited to attend this international event being organised by Bournemouth University and sponsored by the UK Institution of Mechanical Engineers (IMechE), the UK Institution of Engineering Designers (IED) and the International Journal of Life Cycle Assessment. The conference is scheduled to take place on England's central south coast which is surrounded by some of Britain's most delightful and unspoilt countryside.

Product developers need to be aware of recent developments in general tribological fields to be able to address issues which satisfy more than one specific domain. These issues range from those which are product specific to global. Wear and friction between interacting surfaces influence these concepts over the product life cycle with the ensuing environmental and economic consequences. Studies in the past have shown that the economic repercussions of these design decisions were too great to be ignored. Recent concerns on product sustainability and environmental impact require that factors affecting these issues, such as the choice of materials and lubricants, need to be re-addressed. To this effect this forum, chaired by Sir Gordon Higginson, will discuss existing ideas as well as new research falling within the list of topics given below.

- Life-oriented products
- Product life design tools
- Energy studies in product use phase
- Surface quality
- Surface engineering
- Advanced materials
- Sustainable product development
- Life cycle assessment for optimised products
- Environmental impact assessment
- Lubricants
- Analytical studies

Should you require further information for participating in this international event please do not hesitate to visit our website on www.designforlifecycle.org/ted2000. Further information may also be obtained by contacting Mrs Christine Thwaites, Conference Secretariat, TED2000, Bournemouth University, Studland House, 12 Christchurch Road, Bournemouth BH1 3NA, United Kingdom. Alternatively, you may email us for further information at:

ted_info@bournemouth.ac.uk

The International Conference and Exhibition on Life Cycle Assessment: Tools for Sustainability

Date: April 25-27, 2000
Location: Crystal City Hyatt, Arlington, Virginia, Washington DC Metro Area
Contact: InLCA.CI@epamail.epa.gov

Sponsored by
- USEPA's National Risk Management Research Laboratory
- National Center for Environmental Research and Quality Assurance (USEPA)
- Institute for Environmental Research & Education
- Environmental Quality Management Institute

LCA is being developed and applied internationally by corporations, governments, and environmental groups to incorporate environmental concerns into the decision-making process. It is being widely adopted as a means to evaluate commercial systems and develop sustainable solutions. Presentations and discussions during InLCA will focus on approaches that integrate environmental, economic, and social values for decision-making, with emphasis on LCA applications and case studies. The conference will bring together practitioners and decision-makers. peakers will discuss how LCA can be used to:

- *create* marketing advantages
- *improve* environmental decision-making
- *save* organizations money
- *organize* environmental management systems
- *measure* environmental performance and progress towards sustainability
- *communicate* within and outside of organizations.

Fee:
$175 – Early Registration
$200 – Registration after 2/14/00
$150 – Government and Students